The Libyan Journal of Agriculture: volume 6, part 1, 1977

Inheritance of Some Characters in Cucumber, *Cucumis Sativus* L.

I. Powdery mildew resistance and mottling of immature fruit.

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ABSTRACT

The mode of inheritance of powdery mildew resistance and mottling of immature fruit was studied in four inbred lines of the cultivars Baladi, Cool Green, Poinsett and Yomaki. The local cultivar Baladi and the American cultivar Cool Green were susceptible to powdery mildew and their fruits showed no mottling during the immature stage. The American cultivar Poinsett and the Japanese cultivar Yomaki were resistant to powdery mildew and had mottled fruits in the immature stage.

Genetic segregations from nine different crosses between susceptible and resistant parents indicated that resistance to powdery mildew is governed by two pairs of duplicate genes with susceptibility being dominant over resistance. This was true whether Poinsett cultivar or Yomaki was used as the resistant parent. In a cross between the two resistant cultivars Yomaki and Poinsett, the F_1, F_2 and backcross progenies were resistant with very few exceptions of slightly susceptible plants. Apparently the two resistant parents had the same genes for resistance. A possibility exists for the presence of some modifier genes.

Segregations from the nine crosses between parents with mottled and non-mottled immature fruits indicated that mottling was dominant over non-mottling and that this character was governed by one pair of genes.

INTRODUCTION

Cucumber is one of the most popular vegetable crops. The local cultivar 'Baladi' which is the main cultivar grown in Egypt is severely attacked by powdery mildew disease. Among several introduced cultivars, Warid *et al* (12) found that the Japanese cultivar Yomaki was resistant to powdery mildew and that resistance was recessive and governed by two duplicate genes. Abobakr (1) found that the American cultivar Poinsett was also resistant to powdery mildew under Egyptian conditions.

According to Walker (11), the causal organisms of powdery mildew disease are *Erysiphe cichoracearum* D. C. and *Sphaerotheca humili* var. *fuligenia* (Schl.) Salmon. The first of the two organisms is the prevalent one in most parts of the world and apparently

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the most common. The second organism incites the most important powdery mildew on cucurbits in China and has also been reported from Japan and Russia. El Helaly *et al.* (3) showed that powdery mildew in Egypt is caused by *Erysiphe cicharacearum* D. C. and they listed 16 plant species as possible hosts.

Erysiphe cichoracearum D. C. includes numerous physiological races which differ widely in virulence and therefore a cultivar that shows resistance to one strain may be susceptible to the other strains.

Barnes (2) suggested that cucumber powdery mildew resistance was controlled by one or two major recessive genes, with the possibility of one or more minor genes.

In Japan, Hujeda and Akiya (4) crossed the cultivar Natsufushinari which is highly resistant to powdery mildew with Kurume-otiai No. 1 which is susceptible. They found that resistance was recessive and governed by one pair of genes. The causal organism was *Sphaerotheca fuligenea* (Schl.) Pollacci.

Kooistra (5) found that the introductions PI 200815, PI 200818 and the cultivars Vladivostock 155, eihuan-guas, Tyhy-cy and Ashley were slightly resistant to *Sphaerotheca fuligenea*, but the cultivar Natsufushinari and a stock of Indonesian origin were most resistant. A cross of Natsufushinari with PI 200815 and PI 200818 gave some F_2 plants superior to the more resistant parent. There was some indication from the F_2 and F_3 data that resistance was inherited as a recessive character, and that PI 200815 and PI 200818 carried the same genes of resistance while Natsufushinari carried two different genes.

Medvedev (6) found that the cultivars Summer Prolific, Natsufushinari and a Vietnamian type were resistant to *Erysiphe cichoracearum*.

Pivovrov and Yurina (8) found that the cultivars Natsufushinari and Nerosimyi 40 were equally susceptible to *Sphaerotheca fuligenea* during the hypocotyl stage, while Notsufushinari was considerably less affected by the disease than Nerosimyi 40 during the cropping stage.

Shanmugasundarum (9) showed that resistance to powdery mildew in cucumber was controlled by a major recessive gene(s). This gene determined hypocotyl (intermediate) resistance and was also essential for leaf (complete) resistance. Leaf resistance was controlled by a dominant gene (R) which only expressed itself in the presence of the recessive gene(s). Gene (I) was an inhibitory which prevented the expression of complete resistance, but did not affect the gene(s). The genes responsible for resistance in the introductions PI 212233, PI 234517 and the cultivar Natsufushinari appeared to be the same.

With regard to mottling of fruit, Strong (10) showed that the mottled skin of cucumber was dominant and monogenically inherited. Nath (7) found that green fruit color in squash was simply inherited and dominant to yellow at the immature stage of development. Green striped fruit appeared to be dominant over the plain green with monogenic difference. Green striped were dominant to plain yellow. Stripe intensities differed clearly during the different stages of fruit development.

The purpose of this investigation was to study the inheritance of powdery mildew resistance and the mottling of fruit in cucumber.

MATERIALS AND METHODS

This study was conducted in the experimental farm of the Faculty of Agriculture in Minia, and Sids Experimental farm, Egypt. Inbred lines of the four cultivars Balady, Cool Green, Poinsett and Yomaki were used as parents in the present genetic study. Balady is a local cultivar susceptible to powdery mildew. Immature fruits are uniformly green (non-mottled). Cool Green is an American cultivar susceptible to powdery mildew. It produces relatively early female flowers. The fruits are similar in shape and color to those of Baladi. The mature fruit of this cultivar is mottled. Yomaki is a Japanese cultivar resistant to powdery mildew and the immature fruits are mottled.

Ten straight and reciprocal crosses were made between inbred plants of the four cultivars. The first nine crosses were made between resistant and susceptible parents to study the mode of inheritance of this character, while the tenth cross was made between two resistant parents to find out whether the genes responsible for resistance were identical in both resistant parents or not. Crossing started in summer 1972. Two generations were grown each year, as summer and fall plantings. Selfing, crossing and backcrossing continued up to fall 1973 to raise the different generations under study.

All the plants were monoecious and produced male flowers earlier than the female ones. The male and female flower buds that were expected to open in the following morning were tied by cotton filaments in the afternoon. Crossing and selfing were usually made from 6 to 12 a.m. The pollinated flowers were retied with cotton filaments and tagged.

A natural epiphytotic of powdery mildew disease usually occurs each growing season on the experimental ground as well as in the vicinity. The disease symptoms were easily detected on cotyledonary leaves, true leaves and stems. Plants were classified after 60–70 days from sowing to susceptible or resistant according to symptoms on the leaves.

The Chi-square test with and without Yate's correction was applied for the analysis of data.

The mode of inheritance of fruit mottling was studied in the first nine crosses. Color of the immature fruit was visually examined in all the progenies tested and the data were subjected to Chi-square tests.

RESULTS AND DISCUSSION

1. Resistance to Powdery Mildew

Examination of the F_1 plants from the first nine crosses showed that all the F_1 plants from any resistant × susceptible parent were susceptible. This indicates that susceptibility was dominant over resistance in the cultivars under investigation.

F_2 populations, of any susceptible × resistant cultivar, segregated according to the ratio 15 susceptible: 1 resistant. The pooled F_2 of all the studied susceptible × resistant crosses consisted of 4,119 plants which segregated according to the ratio 15 susceptible to 1 resistant (Table 1). It is therefore suggested that powdery mildew resistance is controlled by two pairs of duplicate genes and that the resistant parents carried the recessive genes.

Backcross populations to the susceptible parents were non segregating and susceptible.

As shown from Table 2, the test cross populations were segregating according to the ratio 3 susceptible: 1 resistant and the pooled test cross of all the crosses under the study also segregated in a good fit to 3 susceptible: 1 resistant. This supports the F_2 segregations indicating the existance of two duplicate pairs of genes controlling this character.

F_3 populations were raised from randomly chosen selfed F_2 plants. When the F_2 plants were susceptible, there were three categories of F_3 populations as follows:

1. Populations segregating according to the ratio 15 susceptible: 1 resistant.

Table 1 Expression of powdery mildew resistance in pooled F_2 population of different crosses.

Serial No.	Pedigree[a]	No. of plants: Susceptible	No. of plants: Resistant	Ratio	X^2 Uncorrected	P Range	X^2 Corrected	P Range
1	Baladi pl. 1 × Poinsett 30 pl. 2	303	18	15:1	0.2193	0.50–0.70	0.1259	0.70–0.75
2	Baladi pl. 3 × Poinsett 29 pl. 9	1101	71	15:1	0.737	0.70–0.80	0.0446	0.80–0.90
3	Baladi pl. 12 × Poinsett 29 pl. 22	499	42	15:1	3.9985	< 0.05	3.6386	0.05–0.10
4	Poinsett 29 pl. 22 × Baladi pl. 6	489	35	15:1	0.1649	0.50–0.70	0.0997	0.75–0.80
5	Baladi pl. 15 × Yomaki pl. 15	364	22	15:1	0.1997	0.50–0.70	0.1168	0.70–0.75
6	Cool Green 33 pl. 7 × Poinsett 26. pl. 1	175	17	15:1	2.2222	0.10–0.25	1.8000	0.10–0.25
7	Poinsett 30 pl. 2 × Cool Green 33 pl. 8	610	49	15:1	1.5807	0.10–0.25	1.3848	0.10–0.25
8	Poinsett 32 pl. 14 × Cool Green 33 pl. 8	183	16	15:1	1.0884	0.25–0.30	0.8044	0.30–0.50
9	Cool Green 33 pl. 15 × Yomaki pl. 16	115	10	15:1	0.6533	0.30–0.50	0.3888	0.50–0.70

[a] F_1 Plants of all crosses were non segregating susceptible.

Table 2 Expression of powdery mildew resistance in pooled test cross populations of different crosses.

Serial No.	Pedigree	No. of plants		Ratio	X^2 Uncorrected	P Range	X^2 Corrected	P Range
		Suscept-ible	Resis-tant					
1	Baladi pl. 1 × Poinsett 30 pl. 2	27	11	3:1	0.3158	0.50–0.70	0.1404	0.70–0.75
2	Baladi pl. 15 × Yomaki pl. 15	22	6	3:1	0.1905	0.50–0.70	0.0476	0.80–0.90
3	Poinsett 30 pl. 2 × Cool Green 33 pl. 18	119	22	3:1	6.6407	< 0.05	6.1489	< 0.05
4	Poinsett 32 pl. 14 × Cool Green 33 pl. 15	15	10	3:1	3.000	0.05–0.10	2.6667	0.10–0.25
5	Cool Green 33 pl. 15 × Yomaki pl. 16	38	17	3:1	1.0242	0.30–0.50	0.8727	0.30–0.50

2. Populations segregating according to the ratio 3 susceptible to: 1 resistant.
3. Non-segregation according to the ratio 15 susceptible:1 resistant in F_3 indicates that the selfed F_2 plants were heterozygous with respect to two pairs of genes, whereas those populations which segregated according to the ratio 3 susceptible:1 resistant would indicate that the selfed F_2 plant was heterozygous with respect to one pair of genes.

Table 3 Expression of powdery mildew resistance in parents, F_1, F_2 and backcross populations in the cross Yomaki Pl. 7 × Poinsett 26 Pl. 2.

	Number of plants	
Generation	Susceptible	Resistant
P_1	—	25
P_2	—	14
F_1	1	31
F_2-1	—	62
F_2-2	—	31
F_2-3	—	35
F_2-4	—	68
F_2-5	—	69
F_2-6	—	30
F_2-7	1	116
F_2-8	10	65
F_2-9	—	44
F_2-10	1	28
Bc.P_1-1	—	96
Bc.P_1-2	—	79
Bc.P_1-3	—	44
Bc.P_2-1	—	53
Bc.P_2-2	—	68

As shown in Table 3, the cross between the two resistant parents Yomaki and Poinsett, gave in the F_1 generation 31 resistant plants and one plant slightly susceptible with a few fungus colonies. Ten F_2 populations were raised from selfing F_1 plants. Seven of them were non-segregating resistant whereas three F_2 populations showed a small number of plants with different grades of susceptibility. Backcross populations to either resistant parent were non-segregating resistant plants. Therefore, it may be concluded that the genes controlling resistance in Poinsett and Yomaki cultivars are the same genes. One modifier gene or more might be responsible for the appearance of the slightly susceptible plant out of 32 plants in the F_1 generation, and the few susceptible plants in two out of ten F_2 families.

Warid *et al.* (12) found that resistance to powdery mildew in the Japanese cultivar Yomaki was governed by two recessive duplicate genes designated as pr_1–pr_2. The results of the present investigation confirm such type of inheritance in the cultivar Yomaki and also gives evidence that the resistance to powdery mildew in the cultivar Poinsett is governed by the same genes. Thus the genotype of both resistant parents in the present study would be $pr_1\ pr_1\ pr_2\ pr_2$. The genotype of the susceptible cultivars (Baladi and Cool Green) would be $Pr_1\ Pr_1\ Pr_2\ Pr_2$. There was also some evidence for the presence of modifiers.

Table 4 Expression of mottling of the immature fruit in pooled F_2 populations in different crosses.

Serial No.	Pedigree[a]	No. of plants		Ratio	X^2 Uncorrected	P Range	X^2 Corrected	P Range
		Mottled	Un-mottled					
1	Baladi pl. 1 × Poinsett 30 pl. 2	235	74	3:1	0.1823	0.50–0.70	0.1305	0.70–0.75
2	Baladi pl. 3 × Poinsett 29 pl. 9	819	241	3:1	2.8981	0.05–0.10	2:7786	0.05–0.10
3	Baladi pl. 12 × Poinsett 29 pl. 22	324	108	3:1	0.0000	> 0.99	0.0093	0.90–0.95
4	Poinsett 29 pl. 22 × Baladi pl. 6	393	125	3:1	0.2085	0.50–0.70	0.1647	0.50–0.70
5	Baladi pl. 15 × Yomaki pl. 15	230	86	3:1	0.8270	0.30–0.50	0.7131	0.30–0.50
6	Cool Green 33 pl. 7 × Poinsett 27 pl. 1	219	55	3:1	3.5474	0.05–0.10	3.2895	0.05–0.10
7	Poinsette 30 pl. 2 × Cool Green 33 pl. 8	472	148	3:1	0.4215	0.50–0.70	0.3634	0.50–0.70
8	Poinsette 32 pl. 14 × Cool Green 33 pl. 14	174	42	3:1	3.5556	0.05–0.10	3.2654	0.05–0.10
9	Cool Green 33 pl. 15 × Yomaki pl. 16	87	29	3:1	0.0000	> 0.99	0.0115	0.90–0.95

[a] F_1 plants of all crosses were nonsegregating mottled.

Table 5 Expression of mottling of the immature fruit in pooled test cross populations in different crosses.

Serial No.	Pedigree	No. of plants Mottled	Un-mottled	Ratio	X^2 Uncorrected	P Range	X^2 Corrected	P Range
1	Baladi pl. 1 × Poinsett 30 pl. 2	18	8	1:1	3.8462	< 0.05	3.1154	0.05–0.10
2	Baladi pl. 3 × Poinsett 29 pl. 9	85	72	1:1	1.0764	0.25–0.30	0.9172	0.30–0.50
3	Poinsett 30 pl. 2 × Cool Green 33 pl. 8	54	51	1:1	0.0175	0.80–0.90	0.0000	> 0.99

2. Mottling of Immature Fruit

The inheritance of this trait was studied in the offspring of nine crosses between mottled and non mottled. The pooled data from these crosses are shown in Tables 4 and 5. All the F_1 plants produced mottled fruits indicating that the mottled character was dominant over non-mottled. F_2 populations of all the crosses segregated in a good fit to the ratio 3 mottled:1 non mottled, indicating that this trait is controlled by one pair of genes. Test cross populations segregated according to the ratio 1 mottled:1 unmottled, whereas the backcross populations to the mottled parents were nonsegregating and mottled.

On selfing F_2 unmottled plants, F_3 populations with unmottled fruits were obtained while selfing mottled F_2 plants gave either true breeding mottled populations, or segregating populations (3 mottled:1 unmottled).

The results of the backcross and F_3 populations support the monogenic inheritance of this character with mottled being dominant.

The results of the present investigation on the inheritance of mottling in the immature fruit are in agreement with those obtained by Strong (10).

As far as the preference of the Arab consumer is concerned, the uniform dark green fruit is always preferred. Since the unmottled is a monogenic recessive character, it would be quite easy for the plant breeder to obtain homozygous plants for this character within a fairly short time whenever mottled and non-mottled parents are included in a breeding program.

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